Nanoimaging and Spectroscopy of Emerging Photovoltaic Materials

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Solar energy can deliver the >184 000 TWh per annum required to meet the current worldwide energy needs. Yet, High-performance and low-cost photovoltaics (PV) are still required to successfully substitute fossil fuel-based technologies. Hybrid perovskites and thin-film polycrystalline materials are promising options for high-performance and low-cost PV. These materials present mesoscale constructs, with nano- and microscale grains and boundaries that individually contribute to the devices' optoelectronic behavior [1,2]. For hybrid perovskites, their stability is the primary limiting factor towards commercialization. Thus, we resolve the dynamic optical [3] and electrical [4] responses from the macro- to the nanoscale, as these materials are exposed to: water, oxygen, temperature, bias, and illumination. We further propose a machine learning (ML) tactic to deconvolute the individual and combined effects of each parameter on device stability. We elucidate ion motion within the perovskite grains by a fast scanning probe microscopic new method that enables us to spatially (<20 nm) and temporally (msec) resolve the devices' open-circuit voltage (Voc) (Fig 1) [4,5]. In the realm of polycrystalline materials, we demonstrate a novel AFM-based approach to image local Voc variations, based on illuminated Kelvin-probe force microscopy [6]. Our functional imaging paradigm provides a new platform to map device performance with nanoscale spatial resolution.

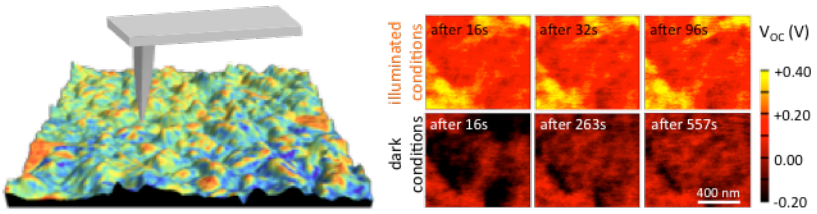

Figure 1 (Left) Schematic of solar cells functional imaging. (Right) Real-time and nanoscale electrical response of perovskite solar cells.

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